Secretary of The Navy Professor

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LONG-TERM GOALS

The goal of this research is to develop a predictive capability for the upper ocean circulation and atmospheric interactions using numerical models.

OBJECTIVE

The immediate objectives are to develop improved models of the oceans, to evaluate these models against available observations, and to develop assimilation techniques to be used in these models. In addition, we are continuing the task of preparing long-term global surface fluxes for use in ocean modeling.

This special ONR Grant is the base support for the FSU Center for Ocean-Atmospheric Prediction Studies. Other agencies who contribute are NASA, NSF, and NOAA.

APPROACH

We are using a suite of models forced with estimates of real winds, with very fine horizontal resolution and realistic basin geometries. The vertical structure ranges from limited resolution, as in the reduced gravity model, to those with very high vertical resolution, as in the multi-layered models and the Princeton model. Much of the modeling work is done in cooperation with the Naval Research Laboratories in Stennis, MS. We have also been examining surface fluxes for use in large-scale numerical ocean models.

WORK COMPLETED

The circulation of the Yellow, East China and Bohai Seas were modeled using the Princeton Ocean Model to better understand the dynamics of the Yellow Sea Warm Current.

Results from multi-layered numerical models were downloaded and analyzed in the region of Hawaii and the Gulf of Alaska. Model transport, velocity, layer thickness and pressure fields were examined. Calculation of water mass transport were done and model validation was carried out by comparison to observations.

We have developed a coupled flux and sea state model that can utilize any one of several wave characteristics to specify the sea state. Variations of the surface temperature in the North Atlantic were analyzed over multi-decadal timescales. Two primary patterns of variation were found.

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RESULTS

The Yellow Sea Warm Current was shown to be present throughout the year, reaching its furthest northward extension in winter (c.f. Fig. 1). Sensitivity tests and spectrum analyses show that winds modify the pathway and extent of the Yellow Sea Warm Current. The current's origin, however, appears to be due to external forcing from the current systems developed in the East China Sea.

The North Hawaiian Ridge Current (NHRC, see Fig. 2) was shown to be a robust surface trapped feature of the mean flow in the central Pacific Ocean. The NHRC manifested from a northern branch of the North Equatorial Current (NEC). The NHRC was found to begin at the bifurcation point of the northern branch of the NEC, leaking 2.0 Sv through the Alenuihaha channel to the lee of the islands, and continuing along the Hawaiian Island chain until it reaches Kauai. The NHRC width scale was consistent with that of an inertial boundary layer. The effects of Ekman pumping/suction, vertical mixing, and the meridional overturning cell on the mean flow were negligible. We found abyssal currents steer upper ocean currents resulting in a northward migration of the bifurcation and enhanced transport north of Hawaii. However, the upper ocean-topographic coupling is not evident in the upper layer currents.

We have developed a coupled flux and sea state model that can utilize any one of several wave characteristics to specify the sea state. The input sea state can be specified through wave age, phase speed of the dominant waves, period of the dominant waves, significant wave height, and significant slope (ratio of significant wave height to the wavelength of the dominant waves). Period and significant wave heights are recorded on an increasing number of National Buoy Data Center (NBDC) buoys, and significant wave height is routinely observed with altimeters. These observations, coupled with wind speed, allow us to determine fluxes without arbitrarily specified sea states. The neutral drag coefficient CD10N (Fig. 3) is shown as a function of wind speed and significant wave height. Note the consistency with the observations that CD decreases as wave height increases (for a fixed wind speed) [Willard Pierson, personal communication, 1998].

A 50-year propagating oscillation and 15-year rotating pattern are found in the North Atlantic sea surface temperature anomaly (SST). COADS SST anomaly fields over much of the North Atlantic are investigated using propagating Complex Empirical Orthogonal Functions (CEOFs) during the period of 1947 to 1992. The first mode (58% of the variance) is a northward propagating feature and the second and third modes combined (about 30% of the variance) is a cyclonically rotating feature within the sub-polar gyre.

IMPACTS

Much of this successful project was conducted as a cooperative effort between Naval and academic personnel. Naval operations can use this information to better understand the local environment, enhancing countermine measures and deployment.

RELATIONSHIP TO OTHER PROJECTS

COAPS manages an ONR Minority Program that currently places 10-15 minority undergraduate science students in a laboratory-type work position with a mentoring professor. The goal is to

convince these students to do graduate studies. Without the basic Secretary of Navy Grant, the ONR Minority Program would not have the infrastructure for the administration.

NSF supports the World Ocean Circulation Experiment Data Assembly Center and Special Analysis Center (WOCE DAC/SAC) for surface meteorology and surface fluxes. This center archives surface meteorological observations from international research vessels as well as develops and validates high-quality surface flux fields, e.g. our tropical Pacific Ocean wind products for El Nino forecasts.

NASA, through a science grant from NASA Headquarters and the NASA Scatterometer Project at JPL, provides support for basic science in utilizing scatterometer data to drive ocean models.

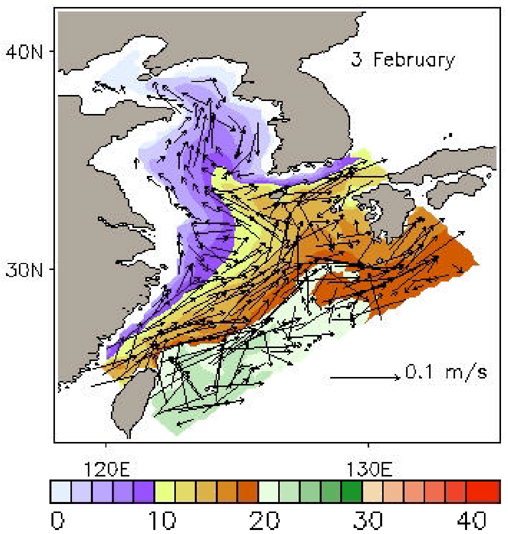

Fig 1. Temperature and currents at 20 m depth from the numerical model of the Yellow Sea. The arrows have been truncated for currents greater than 0.1 m/s.

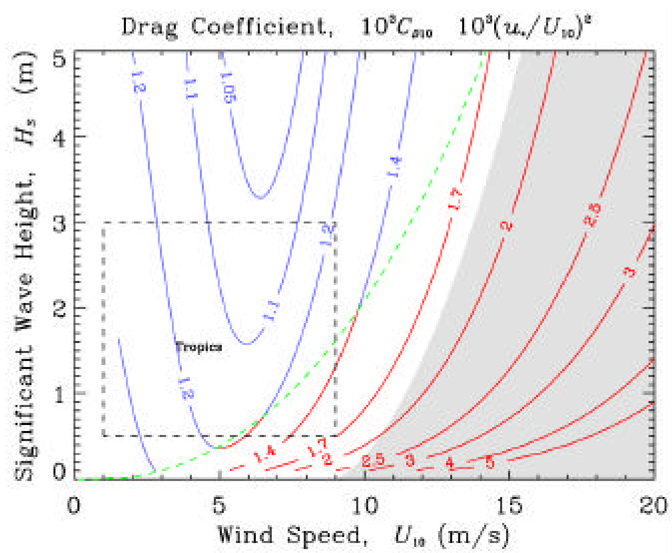

Fig. 3. Modeled drag coefficient (C_D) as a function of wind speed and a significant wave height. Local wind-wave equilibrium is shown by the green dashed line, rising seas are in red, and falling seas in blue. Conditions that require further validation are shown by the gray background.

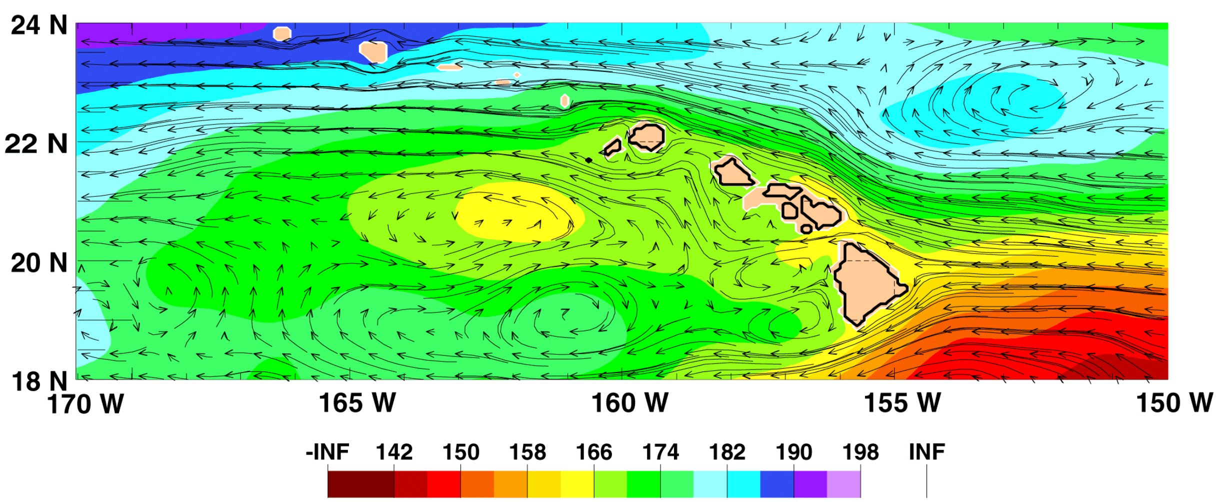

Fig 2. Model results from the region of Hawaii. The surface currents are represented by the arrows. The layer thickness is represented by color.

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PRESENTATIONS

San Francisco, CA	12-10-97	AGU Meeting
New Orleans, LA	01-09-98	Visit NRL-Stennis
San Diego, CA	02-08-98	AGU Ocean Science Meeting
Philadelphia, PA	02-12-98	AAAS Annual Meeting
Biloxi, MS	04-03-98	ONR Meeting on Univ. and Bus. Technology
Iquique, Chile	05-02-98	Inst. of Oceanography Meeting
St. Louis, MO	06-08-98	NOAA/OGP GCIP Climate Conference
Miami, FL	09-08-98	CIMAS Visiting Scientist Program & RSMAS